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XXXIV. *Further Remarks on the Properties of the Coagulable Lymph; on the stopping of Hæmorrhages; and on the Effects of Cold upon the Blood: By the same.*

Read Nov. 22, and
Dec. 6, 1770.

IT has been observed by those who have written on the blood, that it sometimes happens in blood-letting, that the first cup has an inflammatory crust, whilst the last has none; but no satisfactory reason has been given for this appearance. One might suppose that it was owing to a difference in some circumstance in the operation, such as in the velocity with which the blood flowed into each cup, or by the latter being agitated so as to prevent the separation of the lymph: but I have seen it where there was no difference of this sort, nor in any other circumstance that I could observe. I have therefore suspected that in such cases the properties of the blood are changed, even during the time of the evacuation; and in this opinion I am confirmed by the following experiments.

EXPERIMENT XIX.

Nine ounces of blood were taken from a woman who had been delivered two days before, and who at
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that time laboured under a fever, with a considerable pain in her side, and in her *abdomen*. The blood was received into a basin, and her arm was tied up; when, on looking at the blood, I found its surface transparent for some depth, an indication of a future crust; and as her pain was not abated, and her pulse bore it well, I removed the ligature from her arm, and took away about six ounces more, into three tea-cups; but what appeared to me remarkable, although the blood flowed as fast into each of the cups as into the basin, and they were set down immediately when filled on the same window, yet there was no inflammatory crust on that in the cups, though a very dense one on that in the basin. And again, although that in the basin was taken away some minutes before that in the cups, yet it was later in being completely coagulated; as was evident on comparing them.

I had an opportunity of repeating the experiment in the evening; for her symptoms of inflammation seeming equally violent, it was thought proper by the physicians who attended her, to take away more blood; which was done by opening the same orifice, when three tea-cups were nearly filled, and set in the same place; and it was observed, that the first had a crust, though not so thick a one as in the first operation; but the other two cups were without this appearance, though the blood had flowed into them even more quickly than into the first.

EXPERIMENT XX.

A gentleman, who laboured under an inflammatory complaint, had about nine ounces of blood taken from

from his arm. This quantity was divided into four portions; the first was received in a cup, and was in measure little more than an ounce; the second, in a basin, to the quantity of two ounces; the third, in a cup, which held one ounce; and the fourth, in a basin, to the quantity of three ounces. Each vessel was placed immediately upon the window; and it was observed that the blood in the first was latest in coagulating, and had a crust over the whole surface; that in the second, had a crust only upon a part of its surface; but that in the third and fourth had no crust, and manifestly coagulated before either of the other two.

From these experiments it is evident, that the properties of the coagulable lymph can be soon changed; since, in the space of three or four minutes, the disposition to coagulate was increased, and probably too the lymph was thickened. It might indeed, at first sight, seem possible, that blood-letting had only let out the vitiated part; but this is highly improbable; for, suppose a part only of the blood was vitiated, that part must have been equally diffused through the whole mass, and there is no likelihood of its getting out of the vessels before the rest of the blood; and consequently it ought to have appeared in the last equally as in the first cup, but it did not. Bleeding, therefore, in those cases alters the nature of the blood, not by removing the vitiated part, and giving room for new blood to be formed, as has been suspected; but probably by changing that state of the blood-vessels on which the thinness, and lessened tendency of the lymph to coagulation, depends; which surely is a very curious circumstance. This fact

fact is the more remarkable, since it shews the improbability of the opinions of those who maintain that this vitiated blood is the cause of the disease, since the disease remained, though the properties of the blood were changed *.

From this observation we may be led to think, that it may be useful to receive the blood more frequently into small cups, instead of a basin, and to attend more carefully to the alteration produced upon it by bleeding; as we may by that means perhaps learn to determine better, what quantities should be taken away in particular cases. For it would seem probable that the operation is likely to have the most effect on the disease, in those cases where the greatest change is produced by its means, on the disposition of the blood to coagulate; and of that change, we can judge, by comparing the blood in the first cup, with that in the last; for the first cup will nearly shew the state of the blood at the beginning; and the last cup the state of the blood at the latter part of the evacuation.

It frequently happens, that instead of an inflammatory crust over the whole surface of the *crassamentum*, there is only a partial one, which appears in large spots or streaks. In such cases I have observed, that

* That the properties of the blood can be changed by emptying the blood-vessels, is likewise proved by an experiment hereafter to be related; where the blood in an animal in health was found to have its disposition to coagulation increased, in proportion as the vessels were emptied, and as the animal became weaker. It may likewise be necessary to mention, that though the inference is here drawn from two experiments only, yet I have likewise observed the same appearance in other cases, which I have thought it unnecessary to relate.

only a part of the blood had its disposition to coagulate lessened, as in experiment XV. in which some of the blood remained fluid and transparent, where those streaks appeared, for some time after the coagulation had begun in other parts of the surface. Now whether in those cases there had been the same difference before the vein was opened, or whether the whole blood had not been of the inflammatory kind, before venesection, and a part of it was changed as it ran out, or as soon as the general fullness was diminished, may be a question; but the probability, I think, is much in favour of its being changed during the time of the evacuation, from what was observed in the last related experiments.

When I had observed that this disposition of the lymph to coagulate was increased by bleeding, or by weakening the action of the blood-vessels, it occurred to me, that possibly in those cases where the body was very weak, the disposition to coagulate might be so much increased, that instead of being three or four minutes in beginning to do it, after it is let out of the veins (as is the case in people in health) it might coagulate in less time, or almost instantaneously; for I imagined, that unless this took place, we could hardly conceive how the blood should ever have time to coagulate in ruptured vessels, so as to stop hæmorrhages, as it is believed to do. And upon this occasion I recollected an observation of Dr. Hunter's, which is "that the faintness which comes
 " on after hæmorrhages, instead of alarming the by-
 " standers, and making them support the patient by
 " stimulating medicines, as spirits of hartshorn and
 " cordials, should be looked upon as salutary; as it
 " seems

“ seems to be the method nature takes to give
 “ the blood time to coagulate !” As this observation
 seemed to favour my suspicion, I determined to make
 the experiment.

EXPERIMENT XXI.

Believing it would be sufficient for this purpose, to attend to the properties of the blood, as it flows at different times from an animal that is bleeding to death, I therefore went to the markets, and attended the killing of sheep ; and having received the blood into cups, I found my notion verified. For I observed, that the blood, which came from the vessels immediately on withdrawing the knife, was about two minutes in beginning to coagulate ; and that the blood taken later, or as the animal became weaker, coagulated in less and less time ; till at last, when the animal became very weak, the blood, though quite fluid as it came from the vessels, yet had hardly been received into the cup before it congealed. I have also varied the experiment, by receiving blood into different cups at different times, whilst the animal was bleeding to death ; and though the time taken up in killing the animal was not commonly more than two minutes, yet I observed, on comparing the cups, that the blood which issued last coagulated first. I have observed likewise, that the blood coagulates with a different appearance in proportion as the animal becomes weaker ; that which follows the knife begins to coagulate in about two minutes ; it first forms a film or pellicle on the surface, which extends gradually through the whole
 F f f 2 blood,

blood, yet so slowly that its progress may be observed, especially if the pellicle be moved from time to time. But the blood that flows from the fainting animal is coagulated in an instant, after it once begins. From this observation, that the disposition of the blood to coagulate is increased as the animal becomes weaker, we may draw an inference of some use with regard to the stopping of hæmorrhages, viz. not to rouse the patient by stimulating medicines, or by motion, but to let that languor or faintness continue, since it is so favourable for that purpose; and also, that the medicines likely to be of service in those cases, are such as cool the body, lessen the force of the circulation, and promote that languor or faintness*. For in proportion as these effects are produced, the divided arteries become more capable of contracting, and the blood more readily coagulates; two

* Besides giving stimulants and cordials to counteract the fainting, it is a common practice in many parts of England, to give women, who are flooding, considerable quantities of port-wine, on a supposition that it will do them service by its astringency. But surely, from its increasing the force of the circulation, it must be prejudicial in those cases. Perhaps many of the remedies called styptics might be objected to for the same reason.

It has of late been proved by experiments, particularly by those of the ingenious Mr. Kirkland, that the larger arteries, when divided, contract so as to stop the hæmorrhage. But the large *coagula* which we see in the orifices of the vessels of the *uterus* of those who die soon after delivery, and the stopping of hæmorrhages where the blood vessels were ruptured on their sides and not entirely divided, makes me believe that contracting the bleeding orifice is not the only method nature takes to stop an

circumstances that seem to concur in closing the bleeding orifices.

It has been questioned whether blood-letting can be properly recommended in hæmorrhages, excepting in those that are attended with evident signs of *plethora*: but do not these experiments shew, that a vein may be opened with propriety, even where there is no *plethora*, in order suddenly to bring on weakness; by which the momentum of the blood may be so diminished, and the disposition of the lymph to coagulate may be so increased, as to stop the hæmorrhage? For, when we consider how soon the blood-vessels contract, and adapt themselves to the quantity of blood which they contain, it seems not improbable that in some cases where the hæmorrhage is not profuse, but long-continued, the strength of the patient may be so recruited, that the disposition to coagulate shall not be sufficiently increased, or the extremities of the vessels sufficiently contracted, for the stopping of the bleeding; but, by emptying the vessels suddenly, this effect may be produced, and the hæmorrhage may be stopt by the loss of less blood, than would have happened, had only the slow draining been continued.

Although the whitish crust is so commonly seen in inflammatory disorders, and has so very morbid an appearance, as might induce us to consider it as inflammatory, and to bleed repeatedly in all those cases where it occurs, yet I believe we should act improperly: for, to say nothing of pregnancy, in

hæmorrhage. Her resources indeed are great, and she has often more methods than one of producing the same effect.

which

which the appearance is almost constant, there are few physicians that have not seen patients, who, even in such circumstances, have been the worse for this evacuation. Nor need we be surprised that this should happen, considering how soon in some instances this size disappears; and if so, may we not suppose, that it may likewise soon be formed, even by a short exertion of strength in the vessels? Perhaps this was the case in the gentleman mentioned in page 399, who, in less than twenty-four hours after bleeding, had symptoms of great weakness.

As it appears from the above related experiments, that the disposition of the blood to coagulate is increased by bleeding, it may perhaps be useful to attend to this circumstance, and to compare the coagulation of the blood in the last, with that in the first cup, even in cases that are not attended with the inflammatory crust. And it may likewise be worth while to make the same comparison in those cases where every cup has a crust; which frequently happens in rheumatic, and likewise in phthisical complaints. By these means we may judge what effect the evacuation has produced on the strength or fulness of the vessels; and may perhaps, by attending to the last cup, if it contain only a small quantity, be able to guess pretty nearly at the nature of the blood which remains in the body. In the rheumatic case mentioned in page 391, every cup contained this crust; and although the blood in the last cup coagulated in much less time than that in the first, yet as it was later in coagulating than common. I suspected what remained in the vessels had the same disposition;

disposition; but the patient got well without repeating the evacuation.

It may be mentioned here, that I have once or twice seen blood, which, when it first began to coagulate, had on its surface a red pellicle, and underneath a transparent fluid, which afterwards formed a crust. In these cases, if the red pellicle had not been removed before the rest of the blood had congealed, we might have concluded that no part of the blood had this disposition to form a white crust. This appearance, I should imagine, was owing to the blood, where in contact with the air, having coagulated very early, and therefore before the red particles had time to subside, from that part of the lymph which had its disposition to coagulation lessened.

The learned professor de Haen has taken notice of a curious appearance of the blood, which he could not account for; but which, I presume, may be explained from some of the above experiments. His observation is, “ That, having bled a person in a fever, “ the blood was covered with an inflammatory crust, “ and upon examining the *crassamentum* in one of “ the cups, it formed a sort of sack containing a “ clear fluid: this fluid being let out, and the whole “ covered and set by, on examining it next morning, “ a very firm crust covered the whole again, and “ extended to the bottom of the cup*.” I once met with a case similar to this; for, having bled a person into four cups at ten o’clock in the morning, on looking at the blood afterwards, at five in the afternoon, I found the *serum* had not separated from the *crassamentum* in the first cup; but the

* Vide Rat. Medendi, cap. vi.

crassamentum felt as if it contained a fluid in a bag, as professor de Haen has described it. Upon pressing it, the fluid gushed out, which, in a few minutes after being exposed to the air, coagulated : there was however this difference in the two cases, that in mine the fluid was red, so that it formed a red crust over the first, which was white. Now this seems to have been owing to the blood's having first coagulated, where it was in contact with the air and with the sides of the cup; and the fluid which gushed out was the *serum*, with a part of the coagulable lymph, which yet remained fluid; but, when exposed to the air, jellied or coagulated, as it naturally does. That one part of the lymph can remain fluid after the other is coagulated, is proved by some of the preceding experiments; and I have more than once seen blood, which appeared perfectly jellied soon after bleeding; yet, on cutting into the *coagulum*, a transparent fluid has oozed out, which afterwards jellied. And so slowly does this coagulation proceed in some cases, that, in an experiment mentioned before, a part of the blood in a dog's heart was found uncoagulated thirteen hours after death. And I have likewise distinctly observed, that in some cases where the disposition to coagulate was much lessened during the evacuation, the blood at the bottom of the cup has jellied, whilst the greatest part of the *size* at the top was yet fluid; there being only a thin pellicle on its surface, where it was in contact with the air.

Another instance of a change in the properties of this coagulable lymph, which appears curious, was observed in some experiments, where I had occasion
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to throw the blood into water, and oil, during the winter season whilst the heat of the water and oil was no higher than 41° of Fahrenheit's scale. In all those experiments, I found that the disposition to coagulate was lessened, the blood becoming more and more viscid, but did not coagulate whilst in that degree of cold. I shall next relate those experiments.

EXPERIMENT XXII.

The jugular vein being cut out from a rabbit just killed, was thrown into water of 41° of heat, and taken out at the end of half an hour; when the blood was found to be still fluid, though rather more viscid than natural; but, after being exposed to the air for a few minutes, it coagulated.

EXPERIMENT XXIII.

Two pieces of the jugular vein of a dog, just killed, were put into water, in which the thermometer stood at 41° ; one was taken out after twenty minutes, and the other after three quarters of an hour; the blood in both was found to be fluid, and to coagulate afterwards.

As it was evident, from these experiments, that the water had lessened the disposition of the blood to coagulate, I next enquired to what property in the water this effect could be owing; and to see whether water that was warmer would not have the same effect, I made the following experiment.

EXPERIMENT XXIV.

On December the thirteenth, I cut out two pieces of the jugular vein of another dog, immediately after his death. One piece was put into cold water, and the other into water kept warm by a lamp, so that the heat never varied more than between 90 and 100°. At the end of three quarters of an hour, that in the warm water had in it a coagulum as large as a garden pea; but that in the cold water, on being let out into a cup, was found to be quite fluid. Twenty minutes after being exposed to the air, that which had been in the cold water was coagulating; but that from the warm water neither then nor afterwards shewed any signs of farther coagulation: so that it seemed not only to have jellied whilst in warm water, but to have begun to part with its *serum*. From this experiment, it seems probable that the *coldness* was that property of the water to which the lessened disposition to coagulate was owing; but, to be more sure of this, and to see whether the blood might not be kept fluid a longer time by these means, I tried as follows.

EXPERIMENT XXV.

On January the fourteenth, I cut out a piece of the jugular vien of another dog, and put it into oil, in which the thermometer stood at 38°. At the end of six hours it was taken out, and the red particles were observed through the coats of the vein to have in great measure settled to one side.

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The blood was let out into a cup, and was found to be fluid; at the end of fifteen minutes above one half was still fluid; in twenty-five minutes it seemed to be quite jellied. Now as in this experiment a similar effect was produced, as when the vein was put into water, it seems probable that it was the coldness of the water, and of the oil, which had lessened the disposition of the lymph to coagulate.

EXPERIMENT XXVI.

Another piece of the same vein was put into river-water, in which the thermometer stood at 38° , and was left till the next morning; when, after twenty-two hours and a quarter, it was taken out. The particles did not seem to have subsided, as in the former experiment; but the vein being opened the blood was found to be fluid, though so viscid that it could barely drop from the vein. The cup into which it was received was placed upon the window of a moderately warm room, and was examined carefully from time to time; but the blood never had any appearance of coagulation, but remained fluid till it was dried by the evaporation of its water, which happened by the next day. In this experiment the cold seemed intirely to have prevented the coagulation of the lymph: so ill-founded is the common opinion, that cold coagulates the blood.

As the lymph can be deprived of its power of coagulating, on being exposed to the air, by so slight a circumstance, as it would seem, as the cooling it suddenly; it is the less to be wondered at, that such a change should sometimes take place in the blood-

vessels of a living body; an instance of which, I have been told, was observed by the learned professor Cullen, who having ordered an epileptic patient to be bled, the blood was found not to coagulate; but, on bleeding him the day following, the blood coagulated, as usual. A similar instance, I saw lately, by the favour of the medical gentlemen of the British Lying-in-Hospital, who, having bled a woman in a fever that came on soon after delivery, the blood was found not to coagulate on being exposed to the air, but appeared like a mixture of the red particles and serum only; the particles having subsided to the bottom, in the form of a powder. She died three days afterwards; and, upon opening her, we found the blood had coagulated in her vessels after death; and that a dense white *polypus* was formed in each auricle of her heart; one of which, I have now by me. I examined the blood taken away before she died, and found on exposing it to heat, that it did not coagulate sooner than *serum* commonly does, or under 160° : so that it is probable, that at the time she was bled, her blood either was without the coagulable lymph, or that its properties were changed.

After a blow or contusion, the blood now and then bursts from the blood-vessels into the cellular membrane, sometimes forming an *ecchymosis*, and sometimes a tumor; and it is a question with some, whether that blood coagulates or not; but that it coagulates in most of these cases, is proved by the opening of such tumors. Yet it has likewise been observed, that now and then these tumors have been attended with a fluctuation, and after some time their contents have been absorbed: and it has also been found upon opening

opening some of them, even several weeks after the accident, that the blood was fluid. In such cases the blood had probably undergone a change similar to what was observed to take place in some of the preceding experiments; that is, the lymph had been deprived of its property of coagulating, in passing from the blood-vessels into the tumor.